Morphological variance and natural types' division of plus trees of *Larix principis-rupprechtii* Mayr.

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Abstract: The phenotypic characteristics of the plus trees of *Larix principis-rupprechtii* such as stem form, branch angle, branch/stem ratio, branch density, the crown width, crown length, number of short branch over 5-cm branch segment in length, and the leaf number of each short branch were investigated in seed orchard in the Changcheng Mountain, Shaanxi Province. According to the morphological characters, the plus tree clones of *Larix principis-rupprechtii* were classified into 4 natural types: the narrow-dense-crown type, wide-dense-crown type, wide-sparse-crown type, and the narrow-sparse-crown type. The result of the cluster analysis showed there was a very significant difference in tree growth among the four natural types. While comparing the tree growth of four natural types for the last ten years, it was found that the performance order of various types from good to bad is as follows: the narrow-dense crown type > the wide-dense crown type > the wide-sparse crown type > the narrow -sparse crown type. The plus trees of narrow-dense-crown, as a fine type, should be paid great attention to production and prepared to popularize.

Key words: *Larix principis-rupprechtii*, Plus tree, Natural types, Morphological variance
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Introduction

Natural types of trees are regular intraspecific phenomenon. Produced in the phylogenesis process of species, they are results of long-term natural selection. The differences of natural types are often reflected in morphology, even in physiology. Some changes in morphological character of natural types are relatively stable in heredity.

There were once a few study reports on natural types of some tree's varieties at home. Because the difference of phenotypic form is easy to observe and the properties can be easily differentiated quantitatively and qualitatively, the classification of natural types is the classification of morphological types in most cases. For study of natural types of *Larix principis-rupprechtii* Mayr., a report was once made by Hebei Forestry Research Institute. According to branching habit, crown form and flowering feature, the *Larix principis-rupprechtii* was classified into six natural types (Nanjiing College of Forest Product Industry 1980). In Lantian County, Shaanxi Province, one seed forest of *Pinus tabulaeformis* was classified into four natural types based on length of needles, splitting way of the bark and the other characteristics (Zhang Xinbo 1993).

During the establishment of seed orchard of *Larix principis-rupprechtii*, we found that there exists a significant morphological difference among plus trees. Very meaningful, the difference has a close relationship with the growth of trees. Therefore, we made a research on clones in seed orchard of *Larix principis-rupprechtii* in the Changcheng Mountain.

Study methods

For the study of natural types of *Larix principis-rupprechtii*, we started with phenotypic investigation of trees and named the easily differentiated properties. Advantages of carrying out type classification of plus tree clones in seed orchard over stands are as follows:

The investigated trees are under relatively identical environmental conditions. The difference of phenotype is little affected by environmental variance, but mainly influenced by genetic factors. In addition, the wide space between investigated trees eliminated the interaction, which is necessary for *Larix principis-rupprechtii*, a strong heliophilous species. The crown form and the pruning naturally developed without influence of adjacent trees, reflecting the hereditary capacity. In a word, the greatest advantage of type classification on the basis of morphological characters lies in the removal of influence of environmental conditions, making the phenotype and genotype relatively identical. Because the trees growing in the seed orchard are only plus trees of good phenotypic growth in the nature, the natural types mentioned here have limitations and the trees that are not in very good phenotypic growth are not

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included in this study. From another point of view, the aim of our study is not only for study of natural types, but also for selection of fast-growing types. Therefore, it would not be a pity to exclude the types of not very good growth from our study.

Investigation items

For each clone, 3 trees were investigated for replication. All the investigated trees were grafted 13 years ago. Their height and diameter growth in late 10 years were investigated to exclude the influence of grafting and other factors on the initial growth of trees. In addition, the crown width, crown length, number of short branch over 5-cm branch segment in length, and the leaf number of each short branch were investigated, and the buds, growth potential, color, splitting way of bark, and the crown form were recorded. The classified investigation was carried out of following items.

Stem form: The stem form may have 3 types: very straight—the stem has no crook; straight—the stem has one crook and crooked stem—the stem has more than two crooks.

Branch angle: The branch angle means the angle between the first class lateral branch and the stem. It can be classified into 3 types: *oblique type*, there is an acute angle between lateral branches and stems; *horizontal type*, the lateral branch is perpendicular to the stem; and *descending type*, the angle between lateral branches and the stem is larger than 90°.

Branch/stem ratio: It refers to the ratio of mean diameter of the first class lateral branches of the most thick lateral branch ring to the diameter of the stem, indicating the thickness of the lateral branches. When the ratio is > 1/4, the branch is determined as thick, otherwise, as thin.

Branch density: According to the number of short branch over a 10 cm-long branch segment, sampled randomly, the branch density can be determined. When the number of short branches is over 7, it is determined as dense, 5-7, middle, and <5, sparse.

Data analysis

The cluster analysis was used to investigate the property index and the growth index of plus tree clones and to classify them. Then the results of cluster analysis and property classification were compared and checked. The growth difference between different natural types was tested using S test of mathematical statistics.

Result and analysis

Morphological variance of plus trees

It goes without saying that the morphological variance of trees exists generally. The variance mentioned here is only limited and subjected to classification of morphological type and selection of fine natural types.

Variance of structure of plant type

The variance of plant type of trees is mainly determined by crown form and stem form, both being key factors constituting the yield of trees.

Crown form: The plus tree of *Larix principis-rupprechtii* has various crown forms: tower, long cone, cone, and oval. Because of the young age, the growth potential of trees is quite great. So the crown form reflects the growing situation of trees. The ratio of crown width to crown length is 0.52, 0.58, 0.66, and 0.62 for tower crown, long-cone crown, cone crown, and oval crown, respectively. That indicates that the crown width of the first two crown forms is relatively narrow and that of the last two is relatively wide. The results of variance analysis of crown width of 4 crown forms showed a very significant difference between different crown forms, that is, at the 0.01 level, the actual mean square ratio (6.9) is larger than the theoretical value (5.18).

Branching habit: For branching habit, there is a significant difference between various clones. In respect of the branching situation, the branch angle of the first class lateral branch of the first type crown is quite great; the branches are horizontal and thin and slowly extend laterally. The twigs on the branch end of some plus trees are descending. The first class lateral branches of the second type crown extend upwards laterally and have acute branch angles. The branches' crown of this type is thicker than that of the first type and their laterally extending capacity are quite great, often grown to trees with thick branches and wide crown. In respect of the branching capacity of lateral branches, the branching capacity of the first type crown is weaker, resulting in an obvious annual branch layer and sparse and thin crown branches. Since the good transmission inside crown, the natural pruning scarcely occurred; for the second type crown, they often have great branching capacity, obvious annual branch layer, dense crown branches and great growth potential of lateral branches. Once the stem was damaged, the lateral branch can replace the stem easily. As a result of the bad transmission inside crown, the death rate of branchlets inside crown is quite high, flowers and fruits were hardly found in the inner layer of crown, and the fruit-bearing layer shifts outwards obviously. The annual shoot has two regular colors, one yellowish-brown and the other light yellow. There are also some branches with annual shoot color of reddish.

Stem: Most stems are very straight or straight, only a few of stem are crooked. The bark is grayish-brown of dark brown. The bark mainly slips in chips.

Flower variation

Bud scale: The colors of bud scale of male and female flowers are identical in the same tree. The bud scale of various plus trees' clones has two colors: white translucent and brown translucent.

Color of female flowers: Female flowers of some plus trees' clones are light purple, others green. There are also

some clones whose upper part of female flowers is very light purple, the bottom is light green and the middle part is transitional color.

Metamorphosis of flowers: The flowers of *Larix principis-rupprechtii* are unisexual. But it is found that there are also a few of flowers are mosaic monoclinic. The female flowers, composed of many bracts, are on the top of floral axis and the male flowers, made up of several sporidioles, are on the bottom.

Classification of natural types

The plus tree clones in seed orchard are developed under natural conditions and the variations of plant type of them are quite stable and direct visual. The variation has two aspects. One is in width of crown. The ratio of crown width to crown length was used as an index to evaluate the width of crown. When the ratio is smaller than 0.58, it is determined as narrow-crown type, whereas, wide crown type. The other aspect of the variation is in density of branches and leaves. It is different for different clones. The number of short branches over a 5-cm branch segment was used as an index of classification. When the number is >5, it is determined as dense crown type, whereas, sparse crown type. According to mentioned variations of plant type above, the plus tree clones was classified into 4 natural types, that is, narrow-dense crown type, wide-dense crown type, wide-sparse crown type and narrow-sparse crown type.

Narrow-dense-crown type: With stem very straight, the crown is in mainly tower form. There is also some long cone crown with a narrow crown width. The lateral branches grow horizontally or obliquely. The branches are thin and dense. Most of the second-class lateral branches are descending. Naturally pruning is light, The clear bole height is 0.3-0.5 m. Needles are dense and dark green; Grey bark, with fairly thin bark thickness, slipped in chips. The trees have strong apical dominance, fast-growing and middle cone-bearing capacity.

Wide-dense-crown type: Threes have very straight or straight stem, Crown is in forms of with long cone, cone or oval, with wide-crown width. Quite thick lateral branches extend upwards laterally (occasionally extend horizontally). The branches are thick and dense, with strong branching capacity, and annual branch layers is unclear. Good pruning is inside the crown. The cone-bearing layer shifts outwards obviously. The clear bole height is 0.3-0.6 m. needles are dense dark green; bark is thick and coarse, from greyish-brown to dark brown, longitudinal split, This type of trees hasve fast-growing and normal cone-bearing capacity.

Wide-sparse-crown type: Straight or very straight stem, cone and oval-crown, and wide crown width. Fairly thick lateral branches extend upward laterally, strong extending and weak branching capacity. Sparse branches. Good transmitting inside crown, clear annual branch layers, bad natural pruning and 0.6-0.9 m of clear bole height. Light greyish bark. Sparse yellow green needles and middle growing potential and good cone bearing capacity.

Narrow-sparse-crown type: Straight or crooked stem. Long cone or tower crown, small crown width. Lateral branches extend horizontally, bad extending and branching capacities. Clear annual branch layers, thin and sparse branches. Good transmitting inside crown, 0.7-0.9 m of clear bole height. Brown to dark brown bark, thick and coarse bark splits in chips. Sparse yellow green needles. Slowly growing, not very good growth, and good cone-bearing capacity.

In respect of the cone bearing capacity, the sparse crown type bears more cones than the dense-crown type.

Growth of natural types

The selection of fine natural types is bound to associate with the economic goals. In respect of the fast-growing capacity, there is a significant difference between the classified natural types.

Cluster analysis of growth properties

Considering individual and population growth in the stand, three quantitative indexes (height growth, diameter at breast height and ratio of crown width to length) were used to do cluster analysis. As a result, the tree derivation of tree growth of various natural types was drawn up (see Fig. 1). From Fig.1, it can be seen that when a distance coefficient level 27 was adopted, 21 clones can be divided into two groups basically. The clones of narrow-dense crown type and wide dense crown type (except Ma44) were included in one group and the clones of wide-sparse crown type and narrow-sparse crown type (except Ma13) were included in another group Obviously, the two groups show the difference in tree growth between dense-crown types and sparse crown types.

Analysis of growth

Height growth: There is a difference in height growth and height-growing process among the 4 types of plus trees in the last ten years. From the curve of height growth in Fig. 2, it can be seen that the trees with narrow and dense crown perform best, with a relatively uniform growth. For the trees of other three types, the early stage growth of them was not stable until recent 5 years. It is concluded that on height growth, the narrow-dense-crown type was the best, followed by the wide-dense-crown type, the wide-sparse-crown type and the narrow-sparse-crown type in turns.

According to variance analysis of height growth (Table 1), the mean square ration (16.174) of the 4 types was larger than $F_{0.01}$ value (6.11). It indicated that there exists a very significant difference in height growth among them. The multiple comparison of S-test (see Table 2) indicated that between the narrow-dense crown type and the wide-sparse crown type and the narrow-sparse crown type there is a significant difference in height growth. The dif-

ference is not significant between the narrow-dense crown type and the wide-dense crown type. Between the wide-dense crown type and the narrow-sparse crown type the difference is significant, too.

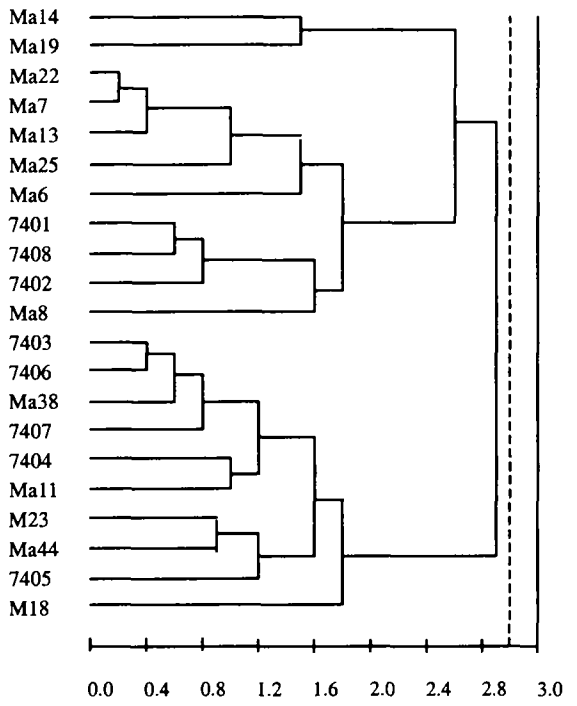

Fig.1 Cluster maps of clones

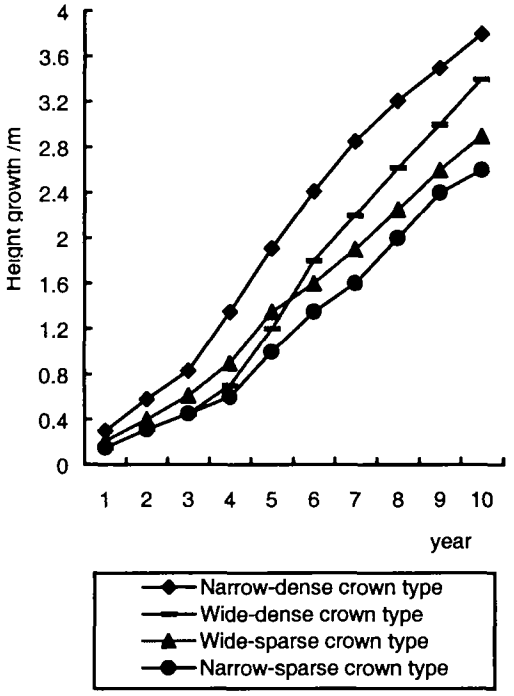

Fig.2 The height growth of 4 types of plus trees of *Larix principis-rupprechtii* for the last 10 years

I : Narrow-dense-crown type; II : Wide-dense-crown type
III: Wide-sparse-crown type; IV:Narrow-sparse-crown type

Table 1. Variance analysis of height growth of 4 types of plus trees of *Larix principis-rupprechtii* for the last 10 years

Source of Variance	Freedom	Quadratic sum of deviation	Mean square	Mean square ratio	$F_{0.01}$
Inter-types	3	6.695	2.232	16.174**	6.11
Mech. error	17	2.349	0.138		
Total	20	9.044			

** Very significant difference

Table 2. Multiple comparison of height growth of 4 types of plus trees of *Larix principis-rupprechtii* for the last 10 years

Natural types	Height growth /m	$\bar{x}_1 - \bar{x}_4$	$\bar{x}_1 - \bar{x}_3$	$\bar{x}_1 - \bar{x}_2$
Narrow-dense-crown type x_1	3.70	1.40*	1.02*	0.20
Wide-dense-crown type x_2	3.50	1.20*	0.82	
Wide-sparse-crown type x_3	2.68	0.38		
Narrow-sparse-crown type x_4	2.30			

* Significant difference

Diameter growth: According to variance analysis (Table 3), the mean square ratio of growth of 4 types for last 10 years (50.87) is far bigger than $F_{0.01}$ value (6.11), that is, the difference among types is very significant (Table 4). This result is identical with the result of multiple comparisons, which means the narrow-dense crown type is better than the wide-sparse crown type and the narrow-sparse crown type in diameter growth, but also with a significant difference. The difference in diameter growth between the narrow-dense crown type and the wide-dense crown type is not significant. The diameter growth of the trees with wide-dense crown is much faster than that of the trees with narrow-sparse crown, also with a significant difference.

In accordance with the above analysis, the tree with dense crown performs better on growth than that with sparse crown. Among the dense-crown types, the narrow crown type had a greatest growth. With fast growing and smaller crown width, a high population yield can be expected. Clone Ma19, Ma17, Ma14, Ma8, Ma25, 7402, 7401 and 7408 are included in this type. The trees with wide and

dense-crown grow quite well, belonging to fast-growing type, including clone Ma44, Ma6, and Ma22. The clones, belonging to the above-mentioned two fast-growing types, take up 52% of 21 investigated clones. The wide-sparse crown type, including clone Ma18, Ma23, Ma13, 7403, 7404, 7405 and 7406, has a normal growth. The clones belonging to this type accounted for 33% of the total clones investigated. The clones, such as Ma11, Ma18 and 7407, belonging to the narrow-sparse-crown type had a bad growth, taking up 15% of the total.

Table 3. Variance analysis of diameter growth of 4 types of plus trees of *Larix principis-rupprechtii* for the last 10 years

Source of Variance	Freedom	Quadratic sum of deviation	Mean square	Mean square ratio	$F_{0.01}$
Inter-types	3	180.9211	60.307	50.87	6.11
Mech. error	17	20.1554	1.187		
Total	20	201.0765			

** Very significant difference

Table 4. Multiple comparison of diameter growth of 4 types of plus trees of *Larix principis-rupprechtii* for the last 10 years

Natural types	Diameter growth /cm	$\bar{x}_1 - \bar{x}_4$	$\bar{x}_1 - \bar{x}_3$	$\bar{x}_1 - \bar{x}_2$
Narrow & dense crown type x_1	7.4	1.9*	1.3*	0.6
Wide & dense crown type x_2	6.8	1.3*	0.7	
Wide & sparse crown type x_3	6.1	0.6		
Narrow & sparse crown type x_4	5.5			

* Significant difference

Conclusion and discussion

The diversity of morphological variation of *Larix principis-rupprechtii* clones is an obvious reality. Paying attention to these obvious variances and finding out the interaction of them with economic properties are just our goals to study and classify the natural types and to select fine types for utilization. Because the structural properties of the plant type, which is closely related with yield, were adopted and the plus tree clones in seed orchard were used as the object of the study, the classification could be considered as the result of influence of genotype or stable hereditary variation.

There is a quite large difference in growing potential and fast-growing capacity among 4 classified natural types of plus trees. The growing speed of the plus trees with narrow and dense-crown is the greatest, followed by those with wide-dense crown, wide-sparse crown, and the narrow and sparse-crown in turns. As a fine type, the narrow-dense-crown type should be paid great attention to production and prepared to popularize. It was believed preliminarily that the latter two types could be sifted out. So, except some clones that were confirmed to be good parent through progeny test they should be used with care for establishment of new seed orchard.

The test work on trees of the natural types studied in this paper should be further strengthened. We could base on performance of progeny to observe the heritability and genetic gains of fine properties of good types. While selecting excellent individual trees, the cross breeding among types should be studied further.

More studies should be done on classification of natural types among the several hundreds collected clones in seed orchard. While perfecting the basis and standards of classification of natural types for selection of new types meeting the demands of the production, the research on propagation methods of new types should be strengthened to provided the production with fine and enough seedlings as soon as possible.

References

Chui Shunchang. 1985. Characteristics of Shaanxi forest plant flora [J] . Shaanxi Forestry Science and Technology, (1): 8-10.

Nanjiing College of Forest Product Industry. 1980. Genetic Breeding [M]. Beijing: Science Press, p5-13

Xu Shuwen. 2000. Resource of tree species quality and division of Shaanxi Province [M]. Beijing: China Forestry Publishing House. p125-123.

Zhang Xinbo. 1993. A Preliminary Investigation into Natural Types of *Pinus tablaeformis* Seed Forest [J]. Shaanxi Forestry Science and Technology, (4): 10-12